Brooklyn Law Review

Volume 82 | Issue 2 Article 10

1-1-2017

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INTERORGANIZATIONAL CHALLENGES TO THE SMART ENERGY TRANSITION IN WASHINGTON STATE

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INTRODUCTION

Now more than a century old, the United States' power grid is a good candidate for an overhaul. America's electrical system was designed to meet the needs of a smaller population that was confronting the economic, political, and technological opportunities and challenges of an earlier era.[1] Today, that same grid is outdated and overused. It operates at the limits of demand capacity under certain conditions;[2] it is increasingly vulnerable to system disturbances and ill-equipped to meet the rapidly changing needs of an ecologically stressed society and planet.[3] In this context, many see the smart grid as a promising approach for building a more efficient, responsive, and sustainable energy system for the twenty-first and twenty-

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1 *See* RICHARD MUNSON, FROM EDISON TO ENRON: THE BUSINESS OF POWER AND WHAT IT MEANS FOR THE FUTURE OF ELECTRICITY 4 (2005).

2 Paul L. Joskow, *Creating a Smarter U.S. Electricity Grid*, 26 J. ECON. PERSP. 29, 29, 34 (2012).

3 *See generally* CLIMATE CHANGE 2014 MITIGATION OF CLIMATE CHANGE: WORKING GROUP III CONTRIBUTION TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2014) [hereinafter CLIMATE CHANGE 2014—MITIGATION OF CLIMATE CHANGE] (This report is a relatively comprehensive assessment of options for mitigating climate change through limiting or preventing greenhouse gas emissions as well as activities that reduce their concentrations in the Earth's atmosphere.); Lauren Reilly, *Automatic Consumer Privacy Rights Embedded in Smart Grid Technology Standards by the Federal Government*, 36 VT. L. REV. 471 (2011) (This article covers some of the principal privacy concerns related to the Smart Grid, and encourages an institutional focus on privacy measures.); Joskow, *supra* note 2 (This article covers many facets of modernizing and expanding transmission and distribution of energy, including demand-response and stimulating investment.).

second centuries.[4] While "smart grid" is an amorphous concept, it generally means "a modernized grid that enables bidirectional flows of energy and uses two-way communication and control capabilities" to allow for new ways of configuring energy systems, functions, and applications.[5]

Smart meters are one key component of the smart grid. Variable in design, smart meters (also called Advanced Metering Infrastructure or AMI) are embedded elements of a larger sociotechnical system.[6] They transmit information about consumer electricity use to utility companies at much smaller time intervals than traditional systems—minute-to-minute rather than month-to-month—which allows utilities to remotely coordinate power supply and demand, detect outages, implement time-of-use and dynamic pricing, and improve system efficiency and reliability in other ways.[7] With appropriate technological interfaces, smart meters also integrate electricity users into the smart grid by allowing them to closely monitor, fine-tune, and reduce energy consumption and consumer costs.[8]

Positive expectations for the smart grid and smart meters tend to run high among policymakers, regulators, engineering and computer science professionals, industrialists, environmentalists, and others.[9] To be sure, this potential is both exciting and daunting. It is exciting because the smart grid appears to offer potential solutions to many different kinds of problems; it is daunting because different organizations and stakeholders define and understand the smart grid in different ways.[10] It is these differences of "technological vision"[11] and

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[4] JENNIE C. STEPHENS ET AL., SMART GRID (R)EVOLUTION: ELECTRIC POWER STRUGGLES 5 (2015).

[5] NAT'L INST. OF STANDARDS & TECH., SMART GRID: A BEGINNER'S GUIDE 3, https://www.nist.gov/sites/default/files/documents/smartgrid/SmartGrid_guide.pdf [https://perma.cc/28B7-RX2V].

[6] For a general discussion of sociotechnical systems, see Thomas P. Hughes, *The Evolution of Large Technological Systems*, *in* THE SOCIAL CONSTRUCTION OF TECHNOLOGICAL SYSTEMS (Wiebe E. Bijker et al. eds., 1989).

[7] *See* Elias Leake Quinn, *Privacy and the New Energy Infrastructure* 8, 11–12 (Ctr. for Energy & Envtl. Sec., Working Paper No. 09-001, 2008).

[8] Jing Liu et al., *Cyber Security and Privacy Issues in Smart Grids*, 14 IEEE COMM. SURVEYS & TUTORIALS 981, 981 (2012), http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.462.4054&rep=rep1&type=pdf [https://perma.cc/AW8X-4LA7].

[9] *See, e.g.*, WHITE HOUSE, FACT SHEET: THE PRESIDENT'S PLAN FOR A 21ST CENTURY ELECTRIC GRID; *About*, SMARTGRID CONSUMER COLLABORATIVE, http://smartgridcc.org/about/ [https://perma.cc/X9MY-Y9TV]; EDISON ELEC. INST., www.eei.org [https://perma.cc/43VS-4PJ4]; *see generally* PETER FOX-PENNER, SMART POWER: CLIMATE CHANGE, THE SMART GRID, AND THE FUTURE OF ELECTRIC UTILITIES (2010).

[10] GILBERT N. SOREBO & MICHAEL C. ECHOLS, SMART GRID SECURITY: AN END-TO-END VIEW OF SECURITY IN THE NEW ELECTRICAL GRID, at xix (2012).

[11] Meinolf Dierkes et al., *Technological Visions, Technological Development, and Organizational Learning*, *in* HANDBOOK OF ORGANIZATIONAL LEARNING & KNOWLEDGE 282 (Meinolf Dierkes et al. eds., 2001).

their implications for sociological theory and energy policy that is our focus in this paper.

Part of a larger ongoing study on the diffusion of smart meters in Washington State, the present analysis uses organizational theory to investigate similarities and differences between key actors in Washington's emerging smart meter field. "Fields" are interactive domains "in which [organizations with] competing interests negotiate over issue interpretation"[12] and make decisions based on relationships with other field actors.[13] The smart meter field involves a wide range of organizational actors including electrical utilities, regulatory agencies, municipalities, power plants, technology firms, universities, national laboratories, and trade associations, among others.[14] Because these actors occupy distinct positions in the field, smart meters and related technologies may mean different things to different actors—a financial investment, a democratization project, a bid for energy independence, progress towards a cleaner energy future, or something else entirely. Such different visions can coexist within a field and influence one another in various ways, but any specific technology necessarily imposes system-wide changes,[15] and our intention is to be sensitive to such changes. Some visions may be complementary and facilitate communication, while others may create problems of communication and give rise to conflict. Because visions can help to coordinate actions within and across organizations, we see the task of identifying the technological visions of relevant actors—and assessing the extent to which they are mutual, complementary, or conflicting—as an important first step in developing a deeper sociological understanding of the role that smart meters will play in the transition to a smart energy system.

The following analysis develops in five parts. Part I begins by situating Washington's smart meter field within a broader historical and national context. Part II presents a theoretical framework that integrates Dierkes et al.'s concept

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12 Andrew J. Hoffman, *Institutional Evolution and Change: Environmentalism and the U.S. Chemical Industry*, 42 ACAD. MGMT. J. 351, 351 (1999).

13 PIERRE BOURDIEU, OUTLINE OF A THEORY OF PRACTICE 17–18 (Ernest Gellner et al. eds., Richard Nice trans., 1977).

14 PHILLIP LAPLANTE, STAKEHOLDER ANALYSIS FOR SMART GRID SYSTEMS 3 (2010), http://paris.utdallas.edu/IEEE-RS-ATR/document/2010/2-Stakeholder%20Analysis%20for%20Smart%20Grid%20Systems_Laplante%20RAMS.pdf [https://perma.cc/QGW7-HUJ9]; LITOS STRATEGIC COMMC'N, THE SMART GRID: AN INTRODUCTION 10, 29 (2008), http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/DOE_SG_Book_Single_Pages%281%29.pdf [https://perma.cc/37NG-C487].

15 *See generally* Jennie C. Stephens et al., *Socio-Political Evaluation of Energy Deployment (SPEED): A Framework Applied to Smart Grid*, 61 UCLA L. REV. 1930 (2014).

of technological vision[16] with Fligstein and McAdam's field theory.[17] Part III briefly describes our methods and data, which derive from interviews conducted in 2015 with individuals representing different smart meter field organizations. We then present the results of our analysis in Part IV. Finally, this article concludes with a summary of our findings and a discussion of their implications for future research and policy.

I. SMART METERS: HISTORICAL AND NATIONAL CONTEXT

In 2003, cascading power outages across several midwestern and northeastern states and Ontario, Canada left 50 million people without power for days.[18] The blackout's proximate cause was that utility companies lacked timely information about the initial outage, and were thus unable to effectively reroute electricity flow that would have prevented working power lines from overloading.[19] By some estimates, the blackout caused $7–$10 billion in economic damages,[20] exposing the increasingly severe limitations of the U.S. energy grid. In response, Congress passed the Energy Infrastructure and Security Act of 2007 (EISA).[21] Intended to move the United States towards greater energy independence and security, Title XIII of EISA focused specifically on the smart grid, calling for a range of technological improvements as well as creating a Smart Grid Task Force.[22] This legislation set in motion the rise of a new and rapidly changing organizational field focused on the sociotechnical development of smart grid systems with smart meter technologies at its core.

Since 2009, funding for smart grid-related research and development (R&D) from public and private sources has totaled

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16 Dierkes et al., *supra* note 11, at 282–98.

17 *See generally* NEIL FLIGSTEIN & DOUG MCADAM, A THEORY OF FIELDS (2012).

18 U.S.-CAN. POWER SYSTEM OUTAGE TASK FORCE, FINAL REPORT ON THE AUGUST 14, 2003 BLACKOUT IN THE UNITED STATES AND CANADA: CAUSES AND RECOMMENDATIONS 1 (2004), http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/BlackoutFinal-Web.pdf [https://perma.cc/PV5Z-WV5W].

19 *Id.* at 30.

20 ELEC. CONSUMERS RES. COUNCIL, THE ECONOMIC IMPACTS OF THE AUGUST 2003 BLACKOUT 1 (2004), http://www.elcon.org/Documents/Profiles%20and%20Publications/Economic%20Impacts%20of%20August%202003%20Blackout.pdf [https://perma.cc/3GKY-XB9Q].

21 Energy Independence and Security Act of 2007, Pub. L. No. 110-140, 121 Stat. 1492 (2007); Alison C. Graab, Note, *The Smart Grid: A Smart Solution to a Complicated Problem*, 52 WM. & MARY L. REV. 2051, 2052–53 (2011).

22 Graab, *supra* note 21, at 2054–55, 2059.

more than $12.5 billion,[23] including $4.5 billion allocated through the American Recovery and Reinvestment Act of 2009 (ARRA).[24] This federal funding stream has been channeled, in part, into new programs aimed at developing smart meters and other "smart" energy-related systems and components. These programs have been conducted by electrical utilities, universities, federal research facilities, and large and small engineering and technology firms across the country.[25] Professional communities of engineers, technicians, and computer scientists have embraced the challenge of smart energy systems with a raft of new conferences, journals, newsletters, websites, and other fora devoted to the smart grid.[26] The same is true of many states, counties, and municipalities, who have partnered with researchers on dozens of federally funded smart grid-related projects on themes ranging from technology development and software applications to consumer behavior and worker training.[27] This organizational activity, along with mounting environmental and economic concerns regarding climate change and slowing global trade,[28] is helping to fuel the growth of knowledge production and technological innovation, as measured by patent applications, published articles, and research grants.[29] Figure 1, below, illustrates the surge in growth that has occurred in the early twenty-first century.

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[23] *Recovery Act: Smart Grid Investment Grant (SGIG) Program*, U.S. DEP'T OF ENERGY, http://energy.gov/oe/information-center/recovery-act-smart-grid-investment-grant-sgig-program [https://perma.cc/35JK-SHRG].

[24] Joskow, *supra* note 2, at 31.

[25] *See generally* U.S. DEP'T OF ENERGY, GUIDEBOOK FOR ARRA SMART GRID PROGRAM METRICS AND BENEFITS (2009), https://www.smartgrid.gov/files/Guidebook_for_ARRA_Smart_Grid_Program_Metrics_Benefits_200912.pdf [https://perma.cc/MK6L-CZYP] [hereinafter GUIDEBOOK FOR ARRA SMART GRID PROGRAM].

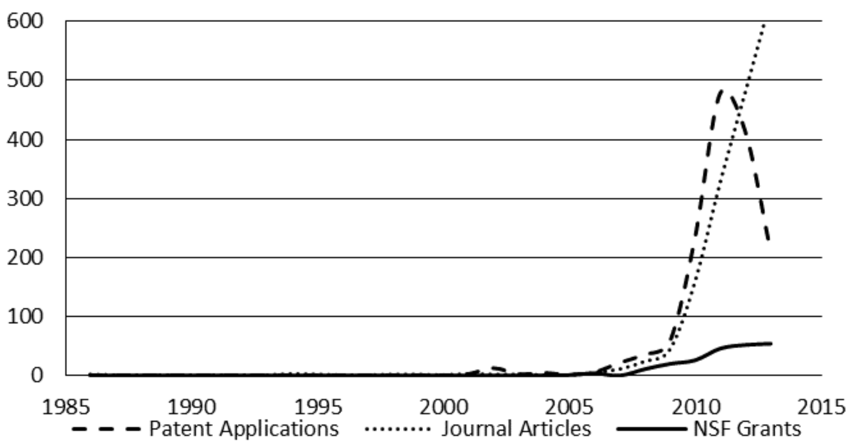
[26] As one example, see *Organizational Purpose*, SGIP, http://www.sgip.org/about-us/organization-purpose/ [https://perma.cc/MNQ8-7RDA].

[27] *See generally Recovery Act: Smart Grid Investment Grant (SGIG) Program*, *supra* note 23.

[28] *See generally* Austin H. Becker et al., *A Note on Climate Change Adaptation for Seaports: A Challenge for Global Ports, a Challenge for Global Society*, 120 CLIMATE CHANGE 683 (2013) (discussing how environmental concerns affect trade and ports specifically); Antoine Dechezleprêtre et al., *What Drives the International Transfer of Climate Change Mitigation Technologies? Empirical Evidence from Patent Data*, 54 ENVTL. & RESOURCE ECON. 161 (2013) (using theories of diffusion to analyze the effects of patent law on global trade and exchanges of ideas); Richard S.J. Tol, *Estimates of the Damage Costs of Climate Change: Part II. Dynamic Estimates*, 21 ENVTL. & RESOURCE ECON. 135 (2002) (estimating some effects of environmental degradation, including climate change specifically).

[29] HELEEN DE CONINCK ET AL., RES. FOR THE FUTURE, INTERNATIONAL TECHNOLOGY-ORIENTED AGREEMENTS TO ADDRESS CLIMATE CHANGE 1–3 (2007); Frank W. Geels, *From Sectoral Systems of Innovation to Socio-Technical Systems: Insights About Dynamics and Change from Sociology and Institutional Theory*, 33 RES. POL'Y 897, 897–98 (2004).

FIGURE 1. Smart Grid- and Smart Meter-Related Patent Applications, Published Articles & Research Grants, 1986–2013[30]



Legal and regulatory changes are additional indicators of this burgeoning field's broad social and economic significance and its organizational heterogeneity. By 2011, all 50 states had enacted a combined 247 changes to their legal codes and regulatory frameworks in ways intended to facilitate smart grid expansion.[31] (21 states had also passed legislation granting specific legal authority to install smart metering devices in homes and offices.)[32] These legal changes, as well as those enacted by states since 2011 and by a growing number of municipalities,[33] have added momentum for the rollout of advanced metering devices. By 2015 there were approximately 64.7 million

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[30] WEB OF SCI. DATABASE (2014), http://www.webofknowledge.com (last visited Apr. 4, 2017) (search for "smart meter*" in active and expired awards); *Patent Application Full Text and Image Database*, US PATENT & TRADEMARK OFFICE, http://appft.uspto.gov/netahtml/PTO/search-bool.html (search for "smart meter" and search for years "1986–2013") (data current through Mar. 30, 2017); *Awards Simple Search*, NAT'L SCI. FOUND., https://www.nsf.gov/awardsearch/ (last visited Apr. 4, 2017) (search for "smart grid", "smart meter", and "advanced meter").

[31] For example, states have passed laws addressing privacy issues associated with smart meters, providing for "opt-out" choices, encouraging net metering, and updating energy efficiency goals. *See* U.S. ENERGY INFO. ADMIN., SMART GRID LEGISLATIVE AND REGULATORY POLICIES AND CASE STUDIES (2011), http://www.eia.gov/analysis/studies/electricity/ [https://perma.cc/2WC7-2MZ7].

[32] *States Providing for Smart Metering*, NAT'L CONFERENCE OF STATE LEGISLATURES, http://www.ncsl.org/research/energy/states-providing-for-smart-metering.aspx [https://perma.cc/7BKM-ZXZV].

[33] *See generally* David J. Hess, *Electricity Transformed: Neoliberalism and Local Energy in the United States*, 43 ANTIPODE 1056, 1063–64 (2011) (Hess's framework permits dynamic interpretation of the history of the U.S. electricity industry, that is sensitive to the various roles of state intervention, legislative and regulatory scale shifts, and the extent to which policies favor elite accumulation or redistribution.).

advanced metering devices installed, including in U.S. homes and commercial buildings.[34]

Yet despite clear evidence of the field's rapid emergence and growing recognition of the central role that the smart grid must play in society's transition to a more sustainable renewable energy system, smart grid development and implementation across the United States has been highly uneven and fraught with unanticipated challenges.[35] Nationally, smart meter implementation strategies and regulatory frameworks lag behind most European Union (EU) member countries.[36] For instance, the landscape of installed smart meters in the EU shows a centralized approach where a legal framework is complemented by a clear implementation structure.[37]

Smart meter implementation varies considerably between the states as well, where its development has been characterized by varying degrees of support (e.g. Texas), resistance (e.g. California), and indifference (e.g. Tennessee).[38] This variation is also mirrored within individual states, such as Washington, where different smart meter implementation projects have been "completed successfully or are in progress with no significant delays or difficulties," while others have not been completed or have stalled out.[39] In 2015, smart meters were installed in over 1.6 million residences and industrial and commercial buildings in Washington State.[40] This share, while small, reflects the sum efforts of a heavily populated and heterogeneous smart meter field composed of at least 261 individual and organizational

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[34] *Frequently Asked Questions: How Many Smart Meters Are Installed in the United States, and Who Has Them?*, U.S. ENERGY INFO. ADMIN, http://www.eia.gov/tools/faqs/faq.cfm?id=108&t=3 [https://perma.cc/SCV6-WTJY] (last updated Dec. 7, 2016).

[35] Seth Blumsack & Alisha Fernandez, *Ready Or Not, Here Comes the Smart Grid!*, 37 ENERGY 61 (2012); *see* GLOBAL SMART GRID FED'N, GLOBAL SMART GRID FEDERATION REPORT 8–11 (2012), https://www.smartgrid.gov/sites/default/files/doc/files/Global_Smart_Grid_Federation_Report.pdf [https://perma.cc/AQS5-PQE4]; *see generally* CLIMATE CHANGE 2014—MITIGATION OF CLIMATE CHANGE, *supra* note 3; Ann Cavoukian et al., *SmartPrivacy for the Smart Grid: Embedding Privacy into the Design of Electricity Conservation*, 3 IDENTITY INF. SOC'Y 275, 275 (2010); Joskow, *supra* note 2.

[36] GLOBAL SMART GRID FED'N, *supra* note 35, at 21; *see generally* SMART REGIONS, EUROPEAN SMART METERING LANDSCAPE REPORT 2012—UPDATE MAY 2013 (2013) [hereinafter EUROPEAN SMART METERING LANDSCAPE REPORT] (This report provides an overview of the state of smart metering in European nations. Based on this data, U.S. installation lags.).

[37] This has resulted in twelve member states enacting a mandatory full smart meter roll-out. EUROPEAN SMART METERING LANDSCAPE REPORT, *supra* note 36, at 3–7.

[38] GLOBAL SMART GRID FED'N, *supra* note 35; *see generally* GUIDEBOOK FOR ARRA SMART GRID PROGRAM, *supra* note 25.

[39] U.S. ENERGY INFO. ADMIN., *supra* note 31, at 1.

[40] *Electric Data Sales, Revenue, and Energy Efficiency Form EIA-861 Detailed Data Files*, U.S. ENERGY INFO. ADMIN. (Oct. 6, 2016), https://www.eia.gov/electricity/data/eia861 (follow 2015 "ZIP" hyperlink; then select "Advanced_Meters_2015" Excel spreadsheet).

actors (see Table 1). Some organizations are large and economically powerful, but most are smaller and claim relatively modest resources.[41] As data presented in Table 1 shows, field actors are broadly distributed across the state, although most organizations concentrate in the heavily urbanized areas west of the Cascade Mountain Range, a few organizations are located outside of Washington altogether.

TABLE 1. Individual and Collective Actors in Washington's Smart Meter Field[42]

		Geographic Location	
Actor Type	Count	Washington	Other States
Power Generators	122	122	0
Power Distributors	68	65	3
Tech. Companies	27	27	0
Academic R&D	6	5	1
Government Agencies	6	4	2
WA Legislators	12	12	0
Prof./Trade Associations	8	2	7
Extra-Gov't Committees	3	1	2
Patent Applicants	5	5	0
Anti-Smart Grid Orgs.	1	1	?
Other	3	3	0
TOTAL	261	247	14

[41] Utility companies range in size, serving anywhere from 30,000 to over a million customers. *See, e.g.*, *About Your PUD*, LEWIS COUNTY PUD, http://lcpud.org/pud/about [https://perma.cc/PXX9-F379]; *Puget Sound Energy Service Area*, PUGET SOUND ENERGY, https://pse.com/aboutpse/PseNewsroom/MediaKit/1213_ServiceAreaMap_web.pdf [https://perma.cc/J4BR-RGJW].

[42] *Participating Members*, SGIP, http://www.sgip.org/membership-benefits/members/ [https://perma.cc/A9DS-XAJM]; *Washington*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/state/?sid=WA [https://perma.cc/YSB7-CMBB]; *Patent Application Full Text and Image Database*, *supra* note 30 (search "smart grid," "smart meter*," and "advanced meter*").

The high level of organizational heterogeneity reflected in Table 1 hints at the potential challenges involved in implementing smart meters in cities and towns across Washington State (and elsewhere). Each set of actors will likely have an individualized understanding of smart meter applications and how they relate to existing energy markets and the larger energy system. Sometimes these visions may be consistent with those of other actors; sometimes their visions will diverge. Thus, the actions that organizations pursue based on their unique visions may facilitate broader implementation of smart meter applications, but they may also interfere. And because organizations in the smart meter field operate in relation to one another, actors' different visions are likely to shape how others make decisions and reorient goals. The next section develops a theoretical framework for more systematically investigating this broader "field of visions."

II. THEORETICAL FRAMEWORK

To date, most existing research on the smart grid and smart meters has taken a relatively narrow view of organizational challenges. Researchers have identified specific mechanisms that encourage implementation, such as legal changes,[43] market pricing,[44] or consumer information campaigns.[45] Other studies identify specific barriers to implementation, such as higher energy bills,[46] legal challenges to privacy statutes,[47] social norms related to emerging technologies,[48] or the mobilization of

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[43] Patrick McDaniel & Stephen McLaughlin, *Security and Privacy Challenges in the Smart Grid*, 7 IEEE SECURITY & PRIVACY 72, 75 (2009); Eoghan McKenna et al., *Smart Meter Data: Balancing Consumer Privacy Concerns with Legitimate Applications*, 41 ENERGY POL'Y 807 (2012).

[44] Daniel Breslau, *Designing a Market-Like Entity: Economics in the Politics of Market Formation*, 43 SOC. STUD. SCI. 1 (2013).

[45] *See generally* Sarah Darby, *Smart Metering: What Potential for Householder Engagement?*, 38 BUILDING RES. & INFO. 442, 446 (2010); Magali A. Delmas & Neil Lessem, *Saving Power to Conserve Your Reputation? The Effectiveness of Private Versus Public Information*, 67 J. ENVTL. ECON. & MGMT. 353 (2013) (This article tests the efficacy of detailed private and public information on electricity consumption and conservation.).

[46] *See* Quinn, *supra* note 7; Cavoukian et al., *supra* note 35; Felicity Barringer, *New Electricity Meters Stir Fears*, N.Y. TIMES (Jan. 30, 2011), http://www.nytimes.com/2011/01/31/science/earth/31meters.html [https://perma.cc/EF6M-2LUX].

[47] Kevin L. Doran, *Privacy and Smart Grid: When Progress and Privacy Collide*, 41 U. TOL. L. REV. 909 (2010); *see* Alfredo Rial & George Danezis, *Privacy-Preserving Smart Metering*, *in* PROCEEDINGS OF THE 10TH ANNUAL ACM WORKSHOP ON PRIVACY IN THE ELECTRONIC SOCIETY 49 (2011).

[48] Christine Horne et al., *Privacy, Technology, and Norms: The Case of Smart Meters*, 51 SOC. SCI. RES. 64, 64 (2015).

public health concerns.[49] Overall, however, extant studies do not offer a framework for understanding how and why the various opportunities and constraints to implementation operate *in relation to one another*.

Institutional theory, a branch of organizational theory, "directs attention toward forces that lie beyond the organizational boundary, in the realm of social processes."[50] For institutional theorists, organizational decisions are not seen as a rational choice within an endless array of possibilities, but rather as decisions made within a narrow set of options that are, in turn, determined by a group of actors operating within the organizational field.[51] Institutional theory offers a deeply sociological perspective, emphasizing the role of social structure, pressures for legitimacy, and norms in organizational decision making. In other words, institutional arguments are "constructionist in the sense that they view the creation of institutions as an outcome of social interaction between actors confronting one another in fields or arenas."[52] This type of analysis seeks to explain social outcomes by looking at the interaction of many actors within a field.

A. *Organizational Fields*

Little used in legal scholarship, field theory[53] provides a useful framework for understanding and explaining meso-level[54] collective outcomes. As a theoretical framework, it analyzes the perspectives, interests, and structural positions of actors within an organizational field or an arena of action at

[49] David J. Hess & Jonathan S. Coley, *Wireless Smart Meters and Public Acceptance: The Environment, Limited Choices, and Precautionary Politics*, 23 PUB. UNDERSTANDING SCI. 688 (2014).

[50] Hoffman, *supra* note 12, at 351.

[51] W. Richard Scott, *Unpacking Institutional Arrangements*, *in* THE NEW INSTITUTIONALISM IN ORGANIZATIONAL ANALYSIS (Walter W. Powell & Paul J. DiMaggio eds., 1991).

[52] Neil Fligstein, *Social Skill and the Theory of Fields*, 19 SOC. THEORY 105, 107 (2001).

[53] Field theory originated in physics and was imported into the social sciences in the 1940s, most notably by psychologist Kurt Lewin. *See* KURT LEWIN, FIELD THEORY IN SOCIAL SCIENCE: SELECTED THEORETICAL PAPERS (Dorwin Cartwright ed., 1951). Key sources in the sociology of fields and field theory include: BOURDIEU, *supra* note 13; Paul J. DiMaggio & Walter W. Powell, *The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields*, 48 AM. SOC. REV. 147 (1983); and John Levi Martin, *What Is Field Theory?*, 109 AM. J. SOC. 1 (2003).

[54] In sociology, analyses are often designated by their scope or level, with "micro-level" referring to studies of small group interactions, "meso-level" referring to interactions among different communities or formal organizations, and "macro-level" referring to studies of interactions among entire societies, populations, or nation-states. For general discussion of these distinctions, see DOYLE PAUL JOHNSON, CONTEMPORARY SOCIOLOGICAL THEORY: AN INTEGRATED MULTI-LEVEL APPROACH (2008).

the level of a collective.[55] Studying the production of social order within and among organizations permits analysts to more precisely understand how social dynamics spread in the aggregate, and how norms, practices, and relationships are challenged, resisted, altered, and institutionalized.[56]

Field theory is sensitive to actors' ability to induce cooperation among other actors within that social order; in other words, it is sensitive to power.[57] It is sufficiently broad to capture a range of relevant actors but also fine-tuned enough to assess relational influences among those actors. Unlike the idea of an institutional logic—which is a relatively fixed set of ideas and relationships among actors[58]—a field frame sees that political action in a field can be consequential.[59] It allows analysts to appreciate, for example, how the transition to a more sustainable energy system does not rest solely on the development of new technologies, the decisions of a particular actor, the ruling of a particular court, or passage of a particular law. Instead, the analysis focuses on the actions of the field as a whole—as the collective patterns of relations among a diverse and changing set of actors.[60] Field theory thus offers an as-yet untapped opportunity for deeper *sociological* understanding of the halting energy transition now underway in Washington and elsewhere.

The defining characteristic of a field analysis is the study of the struggles among actors.[61] Fields are "meso-level social order[s]" through which individual and collective actors "interact with one another on the basis of shared . . . understandings about the purposes of the field, the relationships to others in the field (including who has power and why), and the rules governing legitimate action in the field."[62] Defined as such, fields are characterized by ongoing struggles among actors to define a field's boundaries, criteria for membership, and internal power relations. Fields are highly dynamic social spaces where "what

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[55] *See, e.g.*, Gregg P. Macey, *Boundary Work in Environmental Law*, 53 HOUS. L. REV. 103, 103 (2015) (This article presents a framework for the study of environmental law that emphasizes the institutional arrangements that set and shift boundaries.).

[56] This approach is illustrated by Beth Bechky's study of knowledge-sharing among engineers, technicians, and managers in a large high-tech company. Beth A. Bechky, *Sharing Meaning Across Occupational Communities: The Transformation of Understanding on a Production Floor*, 14 ORG. SCI. 312, 312 (2003).

[57] Fligstein, *supra* note 52, at 106–07.

[58] Royston Greenwood et al., *The Multiplicity of Institutional Logics and the Heterogeneity of Organizational Responses*, 21 ORG. SCI. 521, 522 (2010).

[59] Michael Lounsbury et al., *Social Movements, Field Frames and Industry Emergence: A Cultural-Political Perspective on US Recycling*, 1 SOC.-ECON. REV. 71 (2003).

[60] *See generally* FLIGSTEIN & MCADAM, *supra* note 17.

[61] Fligstein, *supra* note 52, at 107.

[62] FLIGSTEIN & MCADAM, *supra* note 17, at 9.

is at stake" in the field is not given, but contested, not static, but changing.[63] These struggles illuminate how practices evolve and are institutionalized across organizations within the field;[64] they provide insight into the evolution of a field's values and practices.

Importantly for the present article, fields are interrelated, multilevel social structures. Not only is each field composed of different kinds of actors, but fields themselves function in relation to other fields.[65] In the present case, the smart meter field is nested within larger fields defined by the smart grid system and by the geopolitical boundaries of Washington State. Fields can also share some actors in common with geographically proximate fields, such as tech firms based in Oregon or Canada and regional and national associations (such as the Smart Grid Consumer Collaborative). Moreover, fields can be constrained by rules set by "exogenous" regulatory bodies such as the Western Electric Coordinating Council and the Federal Energy Regulatory Commission.[66] Fields can share actors with associated fields (think of the overlap in a Venn diagram), and smaller fields can be nested within larger ones. For instance, cooperatively owned utilities, as a field, are nested within the larger field of energy generation.

When fields are "settled" or stable, actors tend to share similar understandings of what is desirable and have a relatively clear understanding of their particular role within the social order. They can coordinate action because they share taken-for-granted "understandings of what constitutes legitimate goals and how they may be pursued."[67] These taken-for-granted understandings inform organizational behavior, delineating what actors deem desirable, establishing norms and values, and mediating meaning and sense-making. In unsettled times, however, when fields are undergoing rapid change, actors'

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[63] PIERRE BOURDIEU & LOÏC J.D. WACQUANT, AN INVITATION TO REFLEXIVE SOCIOLOGY 111–12 (1992).

[64] *See* Macey, *supra* note 55 (offering a theoretical framework for thinking about how institutions mediate boundaries, and how practices and boundaries are instantiated in institutions).

[65] *See generally* FLIGSTEIN & MCADAM, *supra* note 17 (providing a comprehensive outline of field theory).

[66] *See generally* JACK CASAZZA & FRANK DELEA, UNDERSTANDING ELECTRIC POWER SYSTEMS: AN OVERVIEW OF THE TECHNOLOGY, THE MARKETPLACE, AND GOVERNMENT REGULATION (2d ed. 2010).

[67] Julie Battilana & Silvia Dorado, *Building Sustainable Hybrid Organizations: The Case of Commercial Microfinance Organizations*, 53 ACAD. MGMT. J. 1419, 1420 (2010). For instance, there are several types of energy generating utilities: municipal utilities (publicly held, and whose aim is to provide energy at cost), co-ops, and investor-owned utilities. Taken-for-granted norms in one type of utility may not hold in others. An investor-owned utility will take for granted that its first mandate is to generate profit for its shareholders; municipal utilities may operate under a different logic.

shared understandings are called into question and often contested. In turn, when actors do not enjoy shared, or at least compatible, norms, ideals, and goals that help them make sense of their own and others' actions, they are less likely to coordinate and cooperate.[68]

Field theory offers a particularly useful way for legal and policy scholars to understand and explain institutional changes in areas of law and policy that are dynamically influenced by emerging technologies. Its emphasis on social order and struggle permits analysts to recognize how new *practices*—not just new laws or new policies—are developed and institutionalized. Moreover, by focusing on conflict and competition over resources, the theory offers an alternative to the conventional wisdom that fields are formed primarily around market opportunities[69] and invites analysts to consider the relational contexts that shape struggles across a broad but historically and socially constructed domain: the field. Specifically, in our case, a field-level analysis permits us to emphasize mechanisms that institutionalize meaning around smart meters and understand organizational behavior via processes of meaning-making and framing. One way to chart this progression is to analyze how different actors in the field promote different understandings or "visions" of smart meters in greening the grid and reorganizing electricity distribution.

B. Technological Vision

As conceptualized by organization behavior theorists, a technological vision is not the same as an organization's goals or plans, which tend to be "more concrete, short-term, and limited in scope."[70] Nor are visions composed of the outlandish ideas of fantasy or science fiction. Instead, those who share visions see them as "imaginable and feasible" future organizational-level achievements.[71] Visions operate at the meso-scale within organizations, but "overarching visions" can also operate at a macro-level.[72] At the field level, such visions

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[68] Dierkes et al., *supra* note 11, at 285. For instance, "net neutrality" is something of an unsettled field in the sense that its taken-for-granted ends vary by actors. Some may understand the ultimate goal of net neutrality to be free, public internet service; others may understand the term as nondiscrimination in access and pricing based on user, content, website, platform, application, or mode of communication. Though not necessarily incommensurate, these two visions are substantially different.

[69] Hoffman, *supra* note 12, at 351.

[70] Dierkes et al., *supra* note 11, at 284.

[71] *Id.*

[72] *Id.* at 285.

"transcend boundaries" to integrate organizational actors and guide collective action toward a shared future. Well-known examples of overarching visions include the "paperless office"[73] or the fully automated factory as depicted with dystopic charm in Kurt Vonnegut's 1952 novel *Player Piano*.[74] The "internet of things" (IoT) is another example.[75] As an overarching vision, IoT describes an emerging future society in which "the virtual world of information technology integrates seamlessly with the real world of things."[76] General visions help create stability in the field by permitting actors to develop expectations and recognize their shared interests and common definitions.

Thus, identifying the visions of field actors is a useful first step toward understanding field dynamics—in our case, the changing smart meter field. For the potential of smart meters and related technologies to be fully realized, a variety of actors—utilities, technology companies, researchers, regulators, and the like—will need to coordinate and cooperate. Such coordination is unlikely to occur when actors do not enjoy shared, or at least compatible, visions.[77] Accordingly, our research asked: to what extent do organizational actors in the smart meter field share a common technological vision? To what extent are the technological visions these actors articulate different in important respects? In the smart meter field, is there evidence of a shared vision that is shaping interorganizational dynamics and guiding organizational action? Or is something else happening?

We begin to investigate these questions by analyzing how different key actors in the field describe smart meters, the role smart meters will likely play in an as-yet-unrealized smart energy system, and the challenges those same technologies create for the field. Interviews conducted with smart meter field actors find that many share a rough overarching vision of the smart grid as an IoT. As we describe below, our interviewees carry an IoT vision of the smart grid, imagining a self-sufficient, automated

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73 *Id.*; EDWARD TENNER, WHY THINGS BITE BACK: TECHNOLOGY AND THE REVENGE OF UNINTENDED CONSEQUENCES (1996).

74 *See generally* KURT VONNEGUT, PLAYER PIANO (1952). Revolving around the life of Dr. Paul Proteus, a mechanical engineer and mid-level manager at Ilium Works, the novel sketches a near future society in which machine automation replaces not only factory workers, but technically-trained managers as well. The increasing obsolescence of human ingenuity and labor ultimately gives rise to class conflict, with Proteus and other knowledge workers caught in the middle.

75 SAMUEL GREENGARD, THE INTERNET OF THINGS (2015). The Internet of Things is a system of networking by which objects communicate digitally to collect, exchange, and utilize data, absent any human intervention.

76 ARCHITECTING THE INTERNET OF THINGS 2 (Dieter Uckelmann et al. eds., 2011).

77 DIERKES ET AL., *supra* note 11, at 284–88.

power grid with machine-to-machine communication that, when fully achieved, will be largely independent of human interaction (and thus largely devoid of human error and other such inefficiencies). In this technological vision of a new kind of society, when making decisions, regulators will be increasingly aided by machines—including smart meters and their associated infrastructure—that actors in the field are designing, building, implementing, and integrating. While they may share a general vision, within the context of their own organizations, field actors articulated quite different visions of what smart meters mean and how their implementation is likely to change how the overall field will work.

III. METHODS AND DATA

Our analysis is based on evidence from semi-structured interviews with thirty-two individuals representing Washington-based technology firms, university and national laboratories, electrical utilities, and various consumer advocates. We used a purposive (i.e. nonrandom) sampling process, using existing contacts to gain access to organizational actors.

Our nonrandom sample includes twenty-five men and seven women, nearly all serving in some leadership or managerial position within their organizations.[78] We focused our efforts on people in leadership positions because they often have unique interdepartmental insight and a broad understanding of different job responsibilities. Additionally, they are involved in decision making. Nineteen interview partners have earned post-graduate degrees; four have PhDs. Two-thirds of the individuals we interviewed are seasoned professionals (forty-one to sixty years old), and many have held previous positions in the electrical energy sector. The in-person interviews were conducted in 2014 and involved a semi-structured question format that ranged in length from thirty to ninety minutes. After transcribing the audio interviews, we conducted a basic content analysis of the resulting transcriptions to identify major conceptual themes, including technological vision. To maintain confidentiality, we use pseudonyms, redact informants' specific job titles, locations, and, in some cases, the types of organizations they represent. Together, these interviews offer a window into the ways that competing visions are shaping Washington's emerging smart meter field, which we explore in the following analysis.

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[78] *(n=28).*

IV. RESULTS

Several interviewees representing different types of organizations shared an understanding of the smart grid as a self-sufficient, automated grid featuring real-time machine-to-machine communication. In many of their responses, interviewees equated the smart grid with the IoT or saw the grid as an element of the IoT or closely related to it. This rough overarching vision of the IoT is apparent in several of the quotes we use below to develop our analysis. As these quotes also show, actors' technological visions differed in substantial ways, as described in Table 2. Field theory suggests that such differences may reflect differences in actors' positions and power in the smart meter field[79] and point to the changing structure of relations within it. This section describes the technological visions espoused by field actors working in utilities, academic labs, technology firms, and government regulatory agencies in greater detail, focusing on how the different visions identified in Table 2 reflect changing field conditions overall.

TABLE 2. Technological Visions of Smart Meter Field Actors

Field Actors	Technological Vision "Internet of Things"
Utilities	Energy efficiency
Academic R&D Labs	Automated, self-operating grid
Regulators	Democratization
Technology Firms	Interoperability

A. *Utility Companies*

Utilities have historically been dominant players in energy provision. Traditionally, utilities were monopsony actors with an obligation to ensure that electricity flowed to consumers in a reliable way at a reasonable price—a price that allowed the

[79] *See generally* BOURDIEU, *supra* note 13 (French social theorist Pierre Bourdieu was a seminal thinker within field theory and paid particular attention to issues of position and power in his work.).

utility to remain in business.[80] While utility companies do still care about their bottom lines, they also acknowledge their broader social responsibility. A utility manager described this social responsibility mission this way:

> [W]e like to be advocates for our customers and have them use our product wisely so that their bills are lower. The simple fact of the matter is, our economy is stronger if our customers have more disposable income. For the residential customer, that means they can cycle their money through other parts of the economy rather than through us. For a business customer, it means they can be more competitive with their competitors elsewhere if their rates are lower and if their bills are lower. We are made whole through our regulatory cost recovery mechanisms. Also, customers like to be green and be sustainable. And we can help them do that.[81]

Utilities' interest in providing reliable power at a reasonable cost is reflected in their perceptions of the smart grid. The utility managers tend to hold a vision of the smart grid that valorizes economic efficiency. For these actors, the smart grid offers a practical way to avoid the costs of additional energy generation by using what is currently being produced more efficiently through flexible "load management." As one utility manager described it:

> When you lower the voltage, it reduces the load on the system. So for the first time—that's the flexible grid concept—we can actually impact load without just simply matching it with generation. We can impact it through conservation voltage reduction. So the idea is, if you reduce the load, . . . [y]ou reduce the need for new generation. So there's an avoided cost of new generation. And so that becomes the [new] economic model.[82]

In this quote, incorporating smart meters into the utility's business model represents cost savings through flexible load management.

Similarly, another utility manager noted that "traditionally, we'd have a higher voltage [in town, near the power substation] and anybody outside of the town . . . would get a normal voltage, but people inside the town still get a higher voltage [i.e., more power than they need]."[83] This uneven distribution ensures the necessary voltage range across the grid but also represents cost inefficiency. The same manager continued, "one of the things that we're trying to do is better understand the voltage characteristics so we can lower the

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[80] *See generally* CASAZZA & DELEA, *supra* note 66; DAVID E. NYE, ELECTRIFYING AMERICA: SOCIAL MEANINGS OF A NEW TECHNOLOGY, 1880–1940 (1990).

[81] Interview with Utility Manager 32, in Wash. pp. 3–4, ll. 9–6 (Apr. 2014).

[82] Interview with Utility Manager 25, in Wash. p. 15, ll. 2–15 (Apr. 2014).

[83] Interview with Utility Manager 27, in Wash. p. 18, ll. 15–22 (Apr. 2014).

voltage to a better operating point, so consumers use less energy, so we don't have to make as much energy, another long-term societal benefit."[84] In this comment, the manager expressed his company's desire to lower its voltage level to a more efficient operating point, in which consumers would not have to use as much energy, and the company would be able, in turn, to produce less. Less energy production translates into short-term cost savings to the producer (in this case, the utility in question is a power generator and distributor), but it also means that the utility can meet the rising demand for energy without having to make huge and long-term investments in new power plants. Instead, they meet rising demand for power by more efficiently distributing the electricity they already generate. With these efficiency gains, utilities can claim to reduce the draw-down on natural resource use—especially coal, which is still the major energy source in the United States[85]—and contribute to a more environmentally sustainable energy system in the long run.[86]

This technological vision also promises economic efficiencies on the consumers' end, especially regarding the service that utilities can now provide to businesses and homeowners. For example, one utility management representative, with a technical background, described how his utility's updated grid technology was able to respond to a power outage in a local shopping mall. What traditionally took several hours could be restored within minutes.[87] The self-automated grid function allowed technicians to quickly isolate the affected area and fix the problem, thus avoiding a large negative financial consequence for mall retailers.

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[84] *Id.*

[85] Interview with Academic Research Engineer 06, in Wash. p. 18, ll. 13–21 (May 2014).

[86] Several managers describe how the utilities' efficiency programs help to realize this vision and also respond to consumers' desire for renewable and green sources. Interview with Technology Firm Manager 24, in Wash. p. 14, ll. 17–24 (Nov. 2014); Interview with Utility Manager 32, *supra* note 81, at pp. 3–4, ll. 9–6; Interview with Academic Research Engineer 17, in Wash. p. 8, ll. 12–16 (Nov. 2014); Interview with Technology Firm Manager 26, in Wash. pp. 9–10, ll. 22–26 (Nov. 2014).

[87] The manager continued:

> [G]etting [power to the mall] back on as quickly as possible, I think, is a real economic benefit to them. And so we had the smart grid area there. And so it automatically isolated the fault and then restored customers upstream. And that takes a couple minutes to do, all that configuration. And then the report came out to suggest what they should do downstream. And I think it was within, like, 10 minutes that they had the downstream restored, had most of the mall back on with power, so it was pretty exciting to see that.

Interview with Utility Manager 31, in Wash. p. 10, ll. 10–16 (Apr. 2014).

In addition to potential increases in efficiency and sustainability and improvements in customer service, grid modernization also poses serious challenges for utilities. However, as one research engineer pointed out, "I think that is the smart part [of a smart grid] because, instead of having one power company making all the decisions about supply and demand, now you have everybody collectively making decisions under one mechanism [i.e. smart metering]."[88] Thus, utilities perceive that the smart grid may result in less centralized decision making—and less utility control. This shift is likely to fundamentally alter utilities' relations with other field actors. One example of the new contributions of nonutility actors is that consumers themselves are becoming producers—or "prosumers."[89] In the face of consumer pressure for green energy, "Wal-Mart, Yahoo, Microsoft, Kohl's, Boeing are all putting [small-scale renewable power] generation in."[90] Household customers are also driving electric vehicles and putting solar panels on their roofs. As a senior engineer described it to us, the move to small-scale, renewable power generation is not currently cost-effective in Washington, but the tide is turning. Given increased electricity generation by consumers, it is unclear what business model utilities will need to adopt. As one utility manager told us, the traditional business model "doesn't work very well because, if someone else starts building [AMI, or smart meter] infrastructure and [generating their own power], what happens is, then there's less revenue for the company in regards to utility bills and less need for [an] upgraded [power] plant."[91] On the other hand, "people who can't afford that new generation at their house essentially are burdened with that cost. Right? The same cost has to be covered. So I think there will be a lot of challenges in that."[92]

Another utility representative put the point in even stronger terms, though still framing the grid as a common resource that must be paid for by traditional energy distribution:

> So it's a very different world that we're playing in now . . . the utility is essential because you couldn't put enough solar, you couldn't put enough wind out there to cover all of the needs. There's just not enough rooftops. There's not. And industrial loads that require big energy—so you need the grid. But you need the grid to be viable. So

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[88] Interview with Academic Research Engineer 06, *supra* note 85, at pp. 26–27, ll. 25–4.

[89] Per Goncalves Da Silva et al., *A Survey Towards Understanding Residential Prosumers in Smart Grid Neighbourhoods*, *in* 2012 3RD IEEE PES: INNOVATIVE SMART GRID TECHNOLOGIES EUROPE (ISGT EUROPE) 1–8 (2012).

[90] Interview with Utility Manager 11, in Wash. pp. 26–27, ll. 16–4 (Apr. 2014).

[91] Interview with Utility Manager 25, *supra* note 82, at pp. 8–9, ll. 23–7.

[92] *Id.*

> you need enough people paying for the grid. Otherwise, it'll be too expensive for anybody. So we're in a scary spot where [companies are adopting micro-generators] in essence to try and not pay for the grid, even though we'll be there to back them up.[93]

Both passages above suggest that the transition to a sustainable and green energy system is very much driven by social and economic factors, even as alternative visions for the energy future emerge. While the latter quotation suggests something of a "tragedy of the commons" scenario,[94] the essential dilemma in both is a desire for distributed generation coupled with a need for a costly, centralized grid. Thus, utilities see the potential the smart grid offers for efficiency gains, but they also recognize that these gains may come with a loss of control and threats to profits. These challenges are unsettling the field and altering power relations among field actors.

B. Research Laboratories

Government and university researchers and engineers are not identified as strongly with consumers or constrained by market dynamics as are utilities. Instead, researchers seek to accumulate "scientific capital,"[95] which often takes the form of new grants, publications, conference presentations, awards, and—a practice specific to the smart grid field—the design and implementation of smart meter demonstration projects.[96] All of these practices advance a lab's credibility in the eyes of fellow academics, university administrators, and funding agencies, as well as to other organizational actors in the smart meter field.[97] In their ongoing efforts to accumulate scientific capital, academic engineers and computer scientists work under intense pressure, but it is a very different kind of pressure than that which other actors in the field face. They are, as one

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[93] Interview with Utility Manager 11, *supra* note 90, at pp. 27–28, ll. 19–14.

[94] Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243, 1244 (1968). The "tragedy of the commons" is an economic theory of social behavior within a shared-resource system, wherein individual users, acting independently and according to their own self-interest, behave contrary to the common good of all users by depleting that common resource through their individual actions and consumption. *See id.*

[95] PIERRE BOURDIEU, SCIENCE OF SCIENCE AND REFLEXIVITY 55–56 (Richard Nice trans., 2004).

[96] See examples within PAC. NW. SMART GRID DEMONSTRATION PROJECT, SUCCESS STORIES (2014), https://www.bpa.gov/Projects/Initiatives/SmartGrid/Documents SmartGrid/Success-Stories-Avista.pdf [https://perma.cc/PQP8-NX7A].

[97] For elaboration on field theory, see generally BOURDIEU, *supra* note 95.

researcher put it, "free to envision what could happen by [using] new technologies."[98]

And this freedom—itself a form of pressure to produce novel findings and innovative technologies—builds scientific capital. Unfettered by the daily concerns of business operations and schedules, researchers tend to have more resources to elaborate visions of the future smart grid, in the abstract. "*But research is our business*,"[99] one engineer continued. "So we have more responsibility to think outside the box, figure out something."[100] "Thinking outside the box," as this researcher phrased it, signals a new position for researchers in relation to the shifting role of utilities that are searching for a new business model to make new technologies work in older "boxes."

Unlike utilities, the research labs have little to lose from short-term failure and much to gain in terms of acquiring new knowledge about the limits of the technological systems they are designing. Indeed, their participation in demonstration projects can reveal surprising "side effects"[101] in the sense that every new technology creates unintended and often paradoxical consequences when unleashed into the real world. One researcher described such an "a-ha" moment during a demonstration project when he came to understand the paradoxical side effect of what he called the "vampire load" that smart meters draw from the system:

> [Smart meters] are electronic devices. Therefore, unlike mechanical metering, the devices themselves consume power. So even if every [meter used just] a watt, by the time we replace millions of electromechanical devices with these, then you have a vampire load of, in the U.S., 100 million households, approximately 100 million watts even if they're one watt each.[102]

Smart meters are designed to increase energy efficiency but to do so they must also consume energy. This vampire load paradox complicates the question of whether commercial consumers gain energy efficiency from implementing smart meters and makes it difficult to make a simple business case for large-scale implementation. A similarly paradoxical side effect involves assumptions about labor cost savings: Smart

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98 Interview with Academic Research Engineer 06, *supra* note 85, at pp. 31–32, ll. 16–2.

99 *Id.* (emphasis added).

100 *Id.*

101 Ulrich Beck, *World Risk Society as Cosmopolitan Society? Ecological Questions in a Framework of Manufactured Uncertainties*, *in* ENVIRONMENT 269 (Jules Pretty ed., 2006).

102 Interview with Consumer Advocate 10, in Wash. p. 7, ll. 19–1 (Nov. 2014).

meters will replace highly paid meter reading employees, but the new system will require a whole new set of specialists (such as data analysts and software engineers) to design, set up, and maintain the system.[103] These new specialists often do not show up on utilities' payrolls because they are outsourced.[104] So, do smart meters in fact save on labor costs, or are these costs merely shifted to different areas where they become less visible and harder to accurately calculate? These side effects are the kinds of problems that vastly complicate the business case for smart meters and make life difficult for regulators but that researchers often find intriguing.

Thus, while concerned about grid efficiency and reliability, the data presented above shows that researchers are also techno-utopians who see a fully automated, self-operating smart grid as a way to advance the transition to a sustainable energy system. Whereas utilities managers and directors idealize smart meters as efficiency-generating tools that feature in a more economically robust and environmentally sustainable energy system, the researchers we interviewed hold a more critical view of this technology. Inhabiting the front lines of technological R&D, these researchers draw on their practical experience setting up and studying smart meter pilot projects to question the technological and economic significance of smart meters.[105] Engineers are fluent in this technology and have a specific vision of its promise; their concerns reflect the idea that an imperfect intermediate technology (the smart meter) may ultimately inhibit progression towards the desired end. "I don't think that they are a good gateway to a house or a building,"[106] said one university researcher. This engineer noted that there are "other choices that would probably be better than the meter,"[107] observing that the smart meter made "a good cash register, but I don't think it's a good energy management system."[108]

One reason that smart meters, as currently designed, are not good energy management systems is that while they communicate with the utility, they do not actually communicate directly with the retail consumer despite widespread public

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[103] Interview with Academic Research Engineer 19, in Wash. p. 16, ll. 8–12 (Mar. 2014); Interview with Utility Manager 03, in Wash. p. 11, ll. 8–24 (May 2014).

[104] Interview with Technology Firm Manager 30, in Wash. p. 19, ll. 12–4 (Nov. 2014).

[105] Interview with Utility Manager 11, *supra* note 90, at pp. 26–27, ll. 16–4.

[106] Interview with Academic Research Engineer 07, in Wash. pp. 7–8, ll. 24–3 (Nov. 2014).

[107] *Id.*

[108] *Id.*

perceptions[109] that they can.[110] At present, consumers need access to additional complementary devices (such as smart thermostats or smart appliances) that provide real-time information for managing their energy usage.[111] For academic engineers, smart meter design and implementation thus fall well short of their potential. One senior engineer complained,

> AMI was supposed to be the gateway to demand response.[112] How come we're not rolling out demand response at the same time? If I am at the house putting in a meter, why am I not handing out [smart] thermostats at the same time or when am I going to do this? And we are installing communication networks for the AMI systems that are too weak to do steps two, three, four, and five.[113]

This researcher sees the current situation as a cheaper but, in his words, "short-sighted" investment in AMI deployments that give insufficient attention and investment to future technologies. He continued:

> And to the extent that, [the] network can be beefed up later at no extra marginal cost for doing it incrementally, then I guess we're fine, but I'm very concerned that that's not the case, that when you want to upgrade the communication network, you're basically throwing out the old one and all the costs associated with that and putting in a new one.[114]

Seen this way, smart meters are something of an impediment to the system that research engineers envision for the future smart grid. Such a technological vision, one researcher noted, "would be more proactive instead of

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[109] Chris Mooney, *Why 50 Million Smart Meters Still Haven't Fixed America's Energy Habits*, WASH. POST (Jan. 29, 2015), https://www.washingtonpost.com/news/energy-environment/wp/2015/01/29/americans-are-this-close-to-finally-understanding-their-electricity-bills/ [https://perma.cc/436K-D9SW].

[110] For instance, President Obama at the 2015 National Clean Energy Summit claimed that:

> Six years ago, smart meters were pretty rare. Today, 60 million consumers have access to detailed information about how much energy we use, how we use it, when we use it. So we can use that information to change our habits, use energy more efficiently, save more money without a whole lot of sacrifice.

Press Release, The White House, Remarks by the President at National Clean Energy Summit (Aug. 25, 2015), https://www.whitehouse.gov/the-press-office/2015/08/25/remarks-president-national-clean-energy-summit [https://perma.cc/K9SY-XM6A].

[111] Mooney, *supra* note 109; *see also* Interview with Academic Research Engineer 17, *supra* note 86, at pp. 13–14.

[112] "Demand response" programs refer to efforts by utility companies to manage customer demand—for example, by providing incentives to shift electricity use to nonpeak times. *Demand Response*, DEP'T OF ENERGY, https://www.energy.gov/oe/services/technology-development/smart-grid/demand-response [https://perma.cc/H4KP-5F4T].

[113] Interview with Academic Research Engineer 17, *supra* note 86, at pp. 13–14.

[114] *Id.*

reactive."[115] In this techno-utopian future, data aggregation protocols put in place to protect consumer privacy would mean that "[t]he household where the advanced meter resides would not be unique in its location and how it interacts in the system."[116] Thus, in addition to protecting consumers' privacy, a seamlessly engineered grid that collects data but also continually updates and analyzes data at different scales of aggregation could maximize not just economic efficiency, but bureaucratic, technological, and environmental efficiency as well. Concerning energy costs, for example,

> what's now done through external billing processes and still really only done once a month on some random day near the end of the month, if it's checked at all, could become quite organic to this part of the system if every location is keeping track of what it's done . . . . You would be providing methods for inserting incentives [e.g. to boost demand response] in ways that are much more dynamic and informed than [they are] now.[117]

Embedded in this quote is the real promise that researchers see for the smart grid: an "organic" system, one that is fully integrated, fully automated, and self-correcting, with maximally efficient algorithms all but replacing error-prone and bureaucratically deficient human decision makers.[118] According to the views of many laboratory researchers, the current attention given to smart meters sells this techno-utopian vision short.

C. Consumer Advocate Agencies

For those whose role is protecting consumers, the grid is an opportunity to expand customer access to information and ensure fairness in pricing. In describing his technological vision, one consumer advocate said, "I envision . . . smart meters as the lynchpin of [the internet of things]."[119] In this vision, smart meters are democratizing tools because they have the potential to bring the locus of decision making closer to the public. He continued,

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[115] Interview with Academic Research Engineer 18, in Wash. p. 25, l. 4 (Nov. 2014).

[116] *Id.* at p. 25, ll. 4–7.

[117] *Id.* at pp. 24–25, ll. 21–20.

[118] See generally Emma Marris, *Upgrading the Grid*, 454 NATURE 570–73 (2008) and STEPHENS et al., *supra* note 4 for discussion on how smart grid and demand management technologies are co-evolving in a way that would permit electricity to spontaneously reroute itself along any other path it can find if a transmission line goes dead. It is also worth noting that this vision sees human intervention—in the form of regulators, etc.—as bureaucratic, inefficient, and ultimately harmful to the development of a more perfect energy market. This engineering perspective implies a political vision that is very different from smart-grid-as-democratization notions of the regulators.

[119] Interview with Consumer Advocate 10, *supra* note 102, at pp. 24–25, ll. 575–578.

> I think that smart meters that are two-way communication enabled . . . really are the keys because that will allow the customers to really take control of their usage, to understand what their behaviors are, to be able to see beyond . . . those 15-minute increments, what their usage is [and] be able to understand that, "When I use this device, my power shoots way up," or, "Does this device add this effect?"[120]

In line with the vision of smart meters as a democratizing tool, a highly communicative meter will provide customers with dynamic information that can contribute to consumption decisions multiple times a day in every smart-meter equipped household. In addition to providing customers with information, smart meters also allow regulators and utilities to communicate via prices. As one consumer advocate explained: "[Smart meters] will enable us to move maybe towards more not necessarily real-time pricing, but move them in a direction to have a closer time between what's going on, on the grid and what their customer is paying."[121]

While one respondent stated that regulators' primary role is to control technology (i.e. to "stop things from happening"[122]), most of our research participants expressed a more democratic vision involving a move away from a command-and-control regulatory structure and toward a more open and flexible governance arrangement among power companies, utilities, and regulators. This move is reflected in a discussion that one consumer advocate had with a utility company, whose representatives informed him that,

> they were going forward with their smart grid implementation . . . . But [the company was] talking with us about what their plans were, what their findings were, and doing the research before they started implementation and to get our ideas . . . . [The company] just wanted us to be understanding where they were going with it.[123]

These comments by our respondents suggest that, in the long term, regulators may have less control than they do now. A fully automated smart grid—the kind envisioned by the researchers we described earlier—will be able to use algorithms, machine learning, and real-time power usage data to set and update electricity prices automatically. In this scenario, the work that is currently conducted by regulators will be increasingly accomplished by machine algorithms. In the technocratic utopia envisioned by engineers and computer scientists—which many see as technologically achievable

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[120] *Id.*
[121] *Id.* at p. 25, ll. 582–598.
[122] Interview with Academic Research Engineer 18, *supra* note 115, at p. 25, l. 4.
[123] Interview with Consumer Advocate 10, *supra* note 102, at p. 21, ll. 478–486.

today[124]—market mechanisms, rather than regulators, determine prices. In this idealized future, the field would operate in a highly computer-intensive environment. This vision understands human actions and decisions as unnecessary "interventions" and looks toward the possibility of a perfect market and a better energy system overall, facilitated by computer algorithms.[125]

In the near term, however, regulators in particular face a practical and pressing set of concerns: how to assess the value of smart meters for customers and set prices that appropriately reflect smart meter costs and benefits. Such challenges are reflected in the comment of one analyst regarding the effect smart meters are likely to have on the consumer rate:

> [T]here is a desire to not have prices fluctuate wildly and frequently. So from that perspective, there is some interest in having a stable price, but I think, overarching it, [there is] sort of a dual mandate. One is to make sure that companies are kept whole financially. The other is to make sure that ratepayers don't have to pay any more than [necessary]. So it's a balance.[126]

Such a balance is not easily achieved. Regulators are often overworked and understaffed and, therefore, frequently take cues on technological issues from engineers and computer scientists at universities and national laboratories and from utilities.[127] In addition, the value of smart meters for customers is difficult to assess.[128] Thus, regulators lack the information they need to weigh potential benefits against the price increases that pay for smart meter roll-out.

D. Technology Firms

Finally, technology firms supply the smart grid's proprietary hardware and software, and increasingly, ongoing services.[129] These firms seek competitive advantage in the

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124 This claim emerged independently in several discussions we have had with smart meter field actors.

125 Interview with Technology Firm Manager 16, in Wash. p. 18, ll. 1–16 (Nov. 2014).

126 Interview with Consumer Advocate 10, *supra* note 102, at p. 18, ll. 412–425.

127 Interview with Utility Manager 31, *supra* note 87, at pp. 27–28, ll. 16–1; Interview with Academic Research Engineer 17, *supra* note 86, at. pp. 41–42, ll. 20–5.

128 Interview with Academic Research Engineer 19, in Wash. pp. 14–15, ll. 25–20 (Mar. 2014).

129 As we were told in interviews, tech firms that are now offering individual products, like meters, see the future value of providing "whole solutions" that would include products but also services that help ensure data communication flow, such as leasing as business models or data analytics. Interview with Technology Firm Manager 22, in Wash. p. 26, ll. 16–25 (Nov. 2014).

changing smart grid market.[130] They pursue strategies that will earn profits in the near term and position them for future growth.[131] Traditionally, the energy system has been a field that makes only incremental innovations; our data show that safety, reliability, and legal concerns allow only gradual technological developments. Thus, "for us, and our competitors," said one high-level executive, "everything is hard, and slow, and expensive."[132]

One of the main impediments to the development towards the IoT version of the future grid is the lack of "interoperability"—the ability of different kinds of smart devices to communicate with one another in an open system.[133] At present, such a system does not exist because there is not one single standard for machines to communicate with one another.[134] Instead, all technologies designed to operate on the grid remain proprietary. In the short term, this situation can work to the advantage of individual firms: proprietary technologies keep utilities dependent on a single supplier, and utilities cannot begin purchasing technologies from other firms without changing their entire infrastructure. "[W]ith a proprietary solution, the only person you can get that solution from is the vendor that originally provided it," said one company representative.[135] With an open system that is unified by technological standards for software and hardware, however, "two vendors that have both implemented that standard should be able to interoperate with each other. And so at that point, it becomes open because anybody can participate in that broader ecosystem."[136] In this vision, standardization will enable communication between a virtually limitless number of devices.

While the lack of interoperability may generate significant short-term profits for a select number of suppliers, over the long term, it represents a major challenge to widespread implementation of smart meter technology. Standardization

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130 INT'L TRADE ADMIN., U.S. DEP'T OF COMMERCE, 2016 TOP MARKETS REPORT SMART GRID: A MARKET ASSESSMENT TOOL FOR U.S. EXPORTERS 9 (2016), http://trade.gov/topmarkets/pdf/Smart_Grid_Top_Markets_Report.pdf [https://perma.cc/Y9V7-BU7G].

131 Interview with Technology Firm Manager 14, in Wash. pp. 30–31, ll. 8–7 (Nov. 2014).

132 Interview with Technology Firm Manager 30, *supra* note 104, at p. 23, ll. 12–20.

133 Interview with Technology Firm Engineer 13, in Wash. p. 2, ll. 16–23, pp. 9–10, ll. 184–207 (Nov. 2014); Interview with Technology Firm Manager 16, *supra* note 125, at p. 17, ll. 5–15.

134 Interview with Academic Research Engineer 08, in Wash. pp. 36–37, ll. 12–22 (Apr. 2014); Interview with Technology Firm Manager 02, in Wash. p. 13, ll. 8–25 (Mar. 2014).

135 Interview with Technology Firm Engineer 13, *supra* note 133, at p. 9, ll. 184–191.

136 *Id.*

toward interoperability is an evolving process requiring a level of coordination that does not presently exist in the field. As one respondent described it, "[the] Coalition of the Willing[137] have this vision for how the grid will work in the future and they are trying to get a whole bunch of different vendors to buy into that vision. And it's driven around getting pretty much everything speaking the same protocol."[138] But, as this respondent suggests, to envision and move towards interoperability is a fundamentally political process with high economic stakes.

Our research shows that major questions remain about whose technology will become the standard for the field and what this will mean for the development of proprietary technologies. For tech firms trying to do business in this uncertain field, survival is not assured. A company representative spoke eloquently about this dilemma:

> I think everyone, for the most part, sees this as whether or not they are going to be able to sell their proprietary system. They also see that there's at least some part of the market that's going to demand a standards-based system. And so I think everybody . . . recognizes that, whether you believe it's the right way or not, it's going to be the price of entry in some places. And so it's best to have some input into that standard than to leave it to the competitors that have to have it. And what happens in the standards bodies . . . is, each company that's participating in that standard is participating first to make sure their interests are protected and then, second, make sure that it evolves into something that's going to work.[139]

This respondent's emphasis on protection and survival underscores the uncertainty of survival in such an unsettled field and demonstrates the preexisting, largely financial stakes for those who have already invested in technology and technology development. In addition, this unsettled field lends a boom-or-bust character to the market, adding considerable uncertainty to the mix. Another company representative described his firm's recent experience within a topsy-turvy market:

> We had a real burst of activity when we had the ARRA . . . stimulus funding in 2010 through 2012. And so we had kind of a real spike in activity during that period of time, when there was stimulus funding from the U.S. government. And that's all gone away now. That's all done. And so now, utilities have to justify [their decisions] on the

[137] Here the speaker is referring to members of the Institute for Electrical and Electronics Engineers, or IEEE, a major professional trade association operating in the smart grid field. *See* IEEE, https://www.ieee.org/index.html [https://perma.cc/BCG9-D2SP].

[138] Interview with Technology Firm Engineer 13, *supra* note 133, at p. 17, ll. 386–390.

[139] Interview with Technology Firm Manager 14, *supra* note 131, at p. 23, ll. 6–20.

> basis of a real business case because they're not going to get half of it paid for by the government. And so that has slowed things down.[140]

Thus, some Washington-based technology companies are adopting wait-and-see approaches to R&D. This same interviewee said that his firm would proceed at the "speed of value,"[141] meaning that firms only proceed if the utility companies can show that their product has "value in a business case."[142]

Our interviews with technology company representatives revealed an even more profound type of uncertainty—one that goes beyond prices and the "speed of value." Rather, this additional uncertainty involves the very parameters that define the smart meter/AMI market, reinforcing the idea that the field as a whole is highly unsettled:

> [A]nother power of the internet of things is just using that infrastructure for a whole variety of things. And that's where it may not be one utility that is the end user of this internet of things. It could be a city that is providing a service that people can use. An end user can be getting value out of this. And that's a much harder thing to figure out. From a vendor kind of perspective, who do you market to in that case?[143]

In this example, smart cities will eventually be capable of integrating power generation and distribution, but also transportation, housing, and commerce in one highly complex interconnected system or linked systems.[144] When the entire society becomes tightly integrated in this way, who counts as "the customer" becomes an open question—and one not easily answered.

Thus firms anticipate the need to design technologies that will be used by a range of actors providing multiple services. "[Y]ou may need multiple customers to share an infrastructure to get the cost/benefit of it out. And it's much harder, hard enough to sell things to one customer."[145] Such a highly uncertain economic environment describes the opposite of a settled field populated by an established set of actors running through highly institutionalized scripts.[146] The smart meter

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[140] Interview with Technology Firm Manager 16, *supra* note 125, at pp. 15–16, ll. 23–9. ARRA is the American Recovery and Reinvestment Act of 2009.

[141] *Id.*

[142] *Id.*

[143] Interview with Technology Firm Manager 14, *supra* note 131, at p. 11, ll. 1–12.

[144] Marris, *supra* note 118.

[145] Interview with Technology Firm Manager 14, *supra* note 131, at p. 11, ll. 1–12.

[146] *See* Roger Friedland & Robert R. Alford, *Bringing Society Back In: Symbols, Practices, and Institutional Contradictions*, *in* THE NEW INSTITUTIONALISM IN ORGANIZATIONAL ANALYSIS 232–63 (Walter W. Powell & Paul J. DiMaggio eds., 1991).

field—its configurations, its meanings, and its assumptions—is anything but taken for granted.

CONCLUSION

These four types of organizational actors—utilities, researchers, consumer advocates, and technology firms—share a global technological vision of the smart grid as a key feature of the IoT, and all recognize the central place of smart meters within that larger, evolving grid system. All of these actors also hold a positive view of smart meters and are deeply involved in their design, development, and implementation.

The differences, however, emerge in how actors understand the role of smart meters, and where they see the potential of smart meters for making positive interventions in electricity generation and distribution in the shift to alternative energy systems and green technology. While all actors hold qualitatively "positive" views of smart meters, the field remains unsettled because meanings, markets, and incentives are highly dynamic. Concepts remain abstract, and orientations and perceptions differ among categories of actors. The technology means something different to each of them: a means of economic efficiency, a tool for democratization,[147] a machine-governed system, or the risks of interoperability.[148] We argue that this divergence reflects the fact that the field is unsettled, the positions that actors hold in the field are in flux, and their relationships with one another are uncertain. Utilities are no longer monopsony actors, but face potential competition from prosumers. Regulators, who have traditionally set electricity prices, may play a less central role if market mechanisms are integrated into electricity distribution. Researchers see themselves as becoming "leaders" in the energy transition. Technology firms are reconsidering what it means to base their business models on proprietary research and development.

These differences and uncertainties raise questions about the extent to which the disparate technological visions we identify in this article cohere enough that actors will be able to coordinate to fully achieve the potential benefits that policymakers, technology firm engineers, and academic researchers hope it will bring. To be sure, we find many potential synergies that could be exploited to mutual advantage. For example, technology firms and researchers share an interest in

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147 *See supra* Section III.C.

148 *See supra* Section III.D.

developing and identifying markets for new technologies. Consumer advocates and utilities both seem to share a sense of responsibility towards consumers. Moreover, researcher expertise—"thinking outside the box"—can benefit technology firms, regulators, and utilities who operate under different and tighter legal and economic constraints.

But while the visions of key actors are, in some ways, complementary, comments by research participants also identify areas of potential challenge. Specifically, they demand that we consider how utilities will adapt to a potentially less centralized grid and the changes to their traditional profit model. What is the future of government regulation of prices? How much are consumers really going to be integrated into the grid as active participants or "prosumers"? How are technology companies going to provide meters that meet multiple needs of multiple actors (water, natural gas, telephone, the Internet, etc.)? For actors within the field, these and other unresolved issues remain sources of high uncertainty and potential conflict. For social scientists, these same issues present untapped opportunities to study the dynamics of organizational fields in the nation's halting transition to a more sustainable energy system.

We believe that future social science and policy research should embrace four important challenges that have emerged from the present study. The first challenge is that field-level analyses should be central to this collective research effort.[149] At present, this orientation to theory and method is virtually absent from the existing literature on smart meters and the smart grid. Social scientists and legal scholars should not expect to be able to explain smart meter (and more broadly smart grid) implementation by focusing only on single factors—changes in government regulations, or development of new technological capacities, or market conditions. Instead, future research should include a forthright focus on the smart meter field as a whole—exploring not just the visions of different types of organizational actors, but also their relationships with each other, and how each type of actor adjusts its strategy in response to the behaviors of others in the field. Smart meter implementation depends on the coordinated actions of multiple organizational actors; therefore, understanding the interdependencies among these actors is essential.

A second challenge, implied by the first, is to develop strategies for conducting research across multiple scales and

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[149] Jennie C. Stephens et al., *Getting Smart? Climate Change and the Electric Grid*, 4 CHALLENGES 201, 203 (2013).

geographies. Although we focus on Washington State, field-level analyses have the potential to explain variation in smart meter implementation across state lines, and may also be useful at smaller scales—such as municipalities. A multi-scalar and comparative approach to "fields-within-fields" will be difficult but necessary if our goal is to understand the economic, political, and sociotechnical dynamics shaping energy transition efforts in the United States.

The third challenge, which field theory does *not* directly anticipate, but which in some ways may be the most important in achieving policy impact, is to study consumers as they interact with the smart meter field. Because our study focuses on organizational actors, we do not report data that might illuminate how consumers view their relationships with utilities or how likely they are to change. Nevertheless, fully realizing the potential of smart meters and visions of a decentralized smart grid will require analyses that pay systematic attention to different types of consumers as well as factors affecting different modes of consumer engagement.

Finally, this study reminds us of the importance of thinking outside our disciplinary boxes. Like smart meters, the explanations we render as sociologists or legal scholars are also multivalent—they will be interpreted differently by different stakeholders and implemented (or ignored) in ways that suit decision makers at particular times, places, and settings. To make a difference, the analytical frameworks that researchers employ should be broad and pliable rather than narrow and rigid. We believe field theory has the potential to impact energy policy because it examines the broader relational dynamics of actors—*including energy policy experts and organizations*—that allow us to identify interorganizational challenges and improve the fit between policy goals and outcomes.